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# **Durability of $\text{LiYF}_4$**

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Interdepartmental letterhead

Mail Station L- 493

Ext: 30570

December 29, 1993  
93-122

TO: Glenn Hermes and Howard Powell

FROM: John Tassano and Steve Payne

SUBJECT: Durability of  $\text{LiYF}_4$

It has recently been brought to our attention that the  $\text{LiYF}_4$  (YLF) laser rods utilized in the alignment lasers of Nova tend to "thin" after several years of being exposed to the cooling water solution. As a consequence of this situation the YLF laser rods must occasionally be replaced. Since we found that we were able to minimize the dissolution rate for another fluoride crystal,  $\text{Cr:LiSrAlF}_6$  or  $\text{Cr:LiSAF}$ , by controlling the pH of the solution, we sought to determine if a similar "fix" could be applied to YLF laser crystals as well. For the case of  $\text{Cr:LiSAF}$ , the dissolution rate was observed to vary over 3 orders of magnitude depending on the pH, and a pH = 7 solution was determined to be optimal for improving the durability.<sup>1</sup>

We conducted an experimental campaign to quantitatively assess the impact of pH on the durability of YLF crystals. During these tests we typically employed inspection-polished crystals with a surface area of 0.5-1.0  $\text{cm}^2$ . The YLF crystals were placed in each aqueous solution and then held at an elevated temperature of 70°C in order to enhance the dissolution over the room temperature value, so as to permit more accurate measurements. We examined conditions under which the water was both stirred and unstirred. For each test run, the weight of the crystal was determined within  $\pm 0.1$  mg prior to being immersed in the water solution, and then after a 3-5 day time period in the test solution. This cycle was repeated 3 times to confirm the reproducibility of the experimental results. The durability,  $D_w$ , is reported in units of  $\text{mg}/\text{cm}^2 \cdot \text{day}$ , corresponding to the weight loss of the crystal, normalized by the surface area and the total time period.

Our experimental results are summarized in Table I where the magnitudes of  $D_w$  are listed for pH values ranging from 10.0 to 3.1. The particular solution employed to obtain these pH values is noted in the last column of the table. It is readily apparent from the data in Table I that the durability of YLF tends to substantially degrade for solutions characterized by  $\text{pH} < 6$ . This trend is also evident for the plot of  $D_w$  versus pH displayed in Figure 1. The  $D_w$  values tend to be higher for the stirred circumstances (compared to unstirred) as one would naturally expect, although both sets of data clearly follow the same trend of yielding greatly improved durabilities for  $\text{pH} > 7$ .

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Having observed the strong impact of pH on the magnitude of  $D_w$ , we next sought to obtain an independent qualitative confirmation of this effect. To accomplish this task, we exposed high quality polished YLF crystals to 70°C water solutions of various pH for 4 days. We employed Nomarski microscopy to observe the surface degradation induced by the water solution. The photographs in Figure 2 correspond to the YLF surfaces before and after the 70°C water treatment. It is apparent from the microscopy study that the surface quality became less degraded for the higher pH solutions that were employed. This result is consistent with the trends recognized from the data in Figure 1 and Table I. The photographs of Figure 2 additionally suggest that the durability is further improved in passing from pH 7 to 10.

We can conclude from our experimental campaign that the durability of YLF can be markedly improved by employing cooling solutions characterized by pH values in the range of 7-10. It is important to recognize, however, that the implementation of this type of "fix" for the YLF dissolution problem will require that the water solution remain compatible with the cooling system and also that care be exercised to assure that the additives in the water not color or darken under the influence of ultraviolet light.

  
John B. Tassano

  
Stephen A. Payne

#### Acknowledgments

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#### References

1. S. A. Payne, L. K. Smith, et al., "Properties of Cr:LiSrAlF<sub>6</sub> crystals for laser operation," UCRL-JC-114032.



Table I. Durability results obtained for  $\text{LiYF}_4$  at  $70^\circ\text{C}$  under stirred and unstirred conditions.

pH	$D_w$ ( $\text{mg}/\text{cm}^2 \cdot \text{day}$ ), $\pm 0.01$		Solution type
	Stirred	Unstirred	
10.0	0.006	0.000	$\text{H}_3\text{BO}_3/\text{KOH}$
7.0	0.000	0.000	$\text{KH}_2\text{PO}_4/\text{Na}_2\text{HPO}_4$
6.0	0.018	—	$\text{KH}_2\text{PO}_4/\text{NaOH}$
5.1	0.090	0.037	de-ionized water
3.1	0.17	0.094	$\text{KH}_2\text{PO}_4/\text{NaOH}$

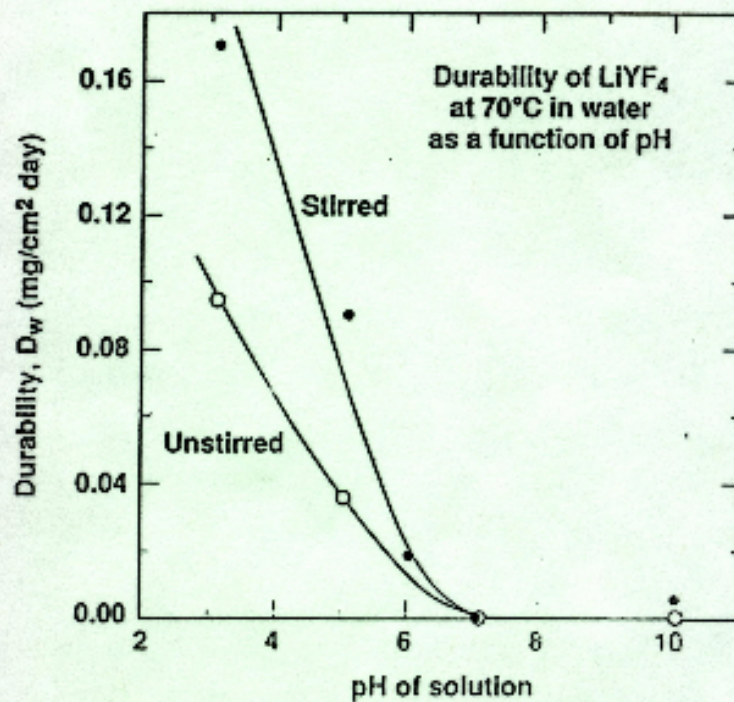
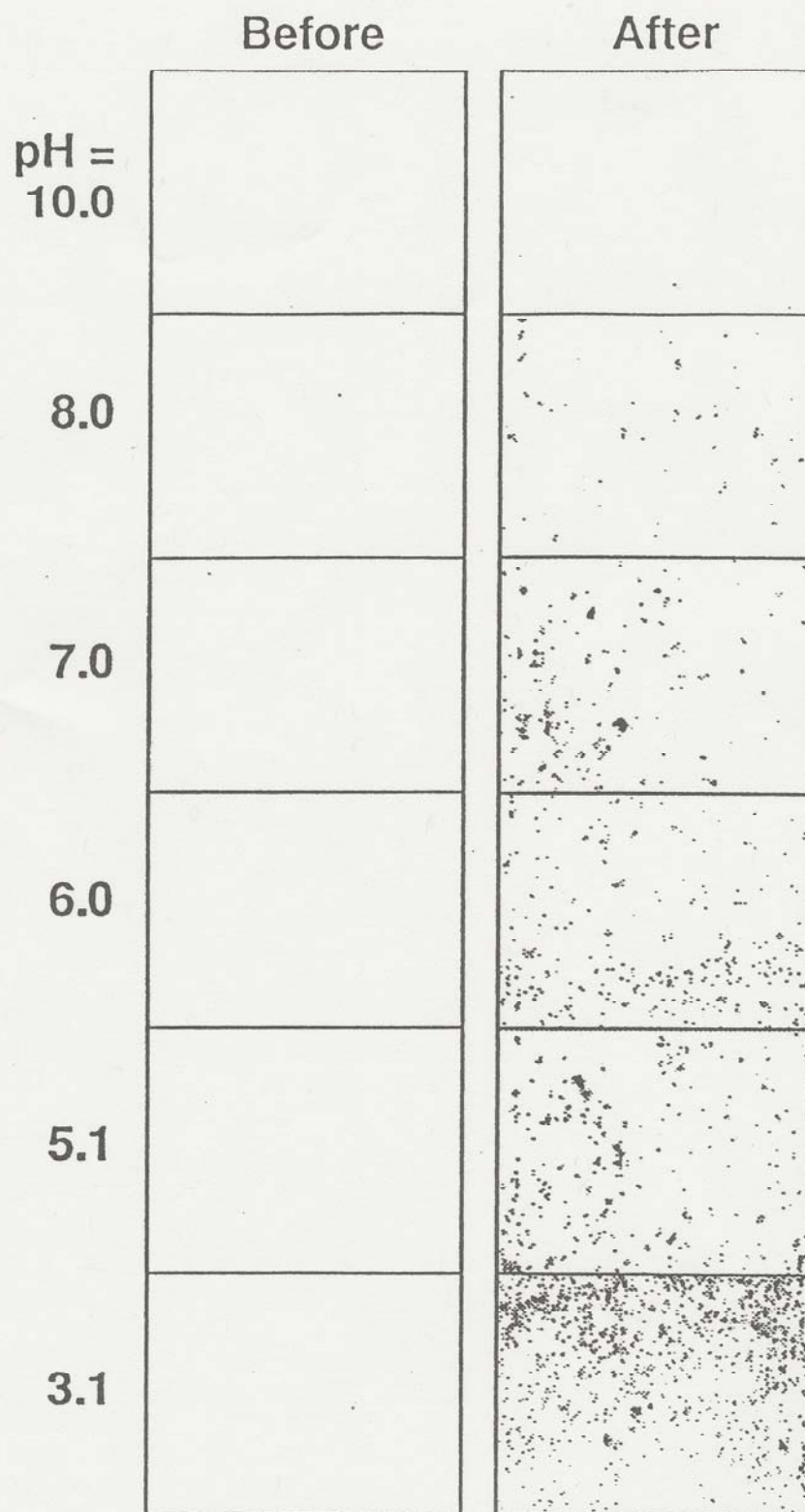


Fig. 1: Durability of YLF as a function of the pH of the water solution.



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Fig. 2: Nomarski microscopy photographs of YLF surfaces before and after 70°C water treatment for 4 days at the indicated pH (images are computer processed).